A (Very) Little Bit About Thermocouples

Rob Candler

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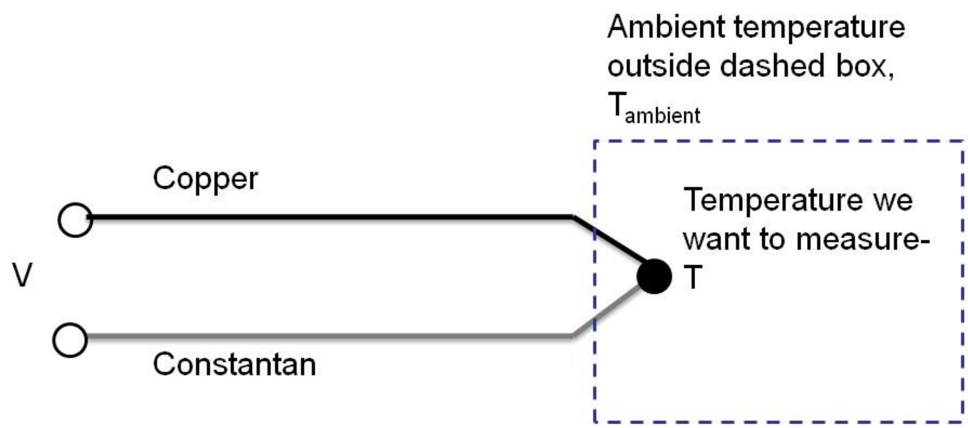
Comments, corrections, and feedback are greatly appreciated!

Consider a metal wire. If there is a temperature gradient across this wire, the electrons in it will redistribute to have a lower concentration at the hot side, which gives rise to a voltage, as described by the Seebeck effect. This voltage is dependent upon material properties. If we electrically connect two wires of different material and place them such that they both experience the temperature gradient, they will have different voltage drops, which we can measure.



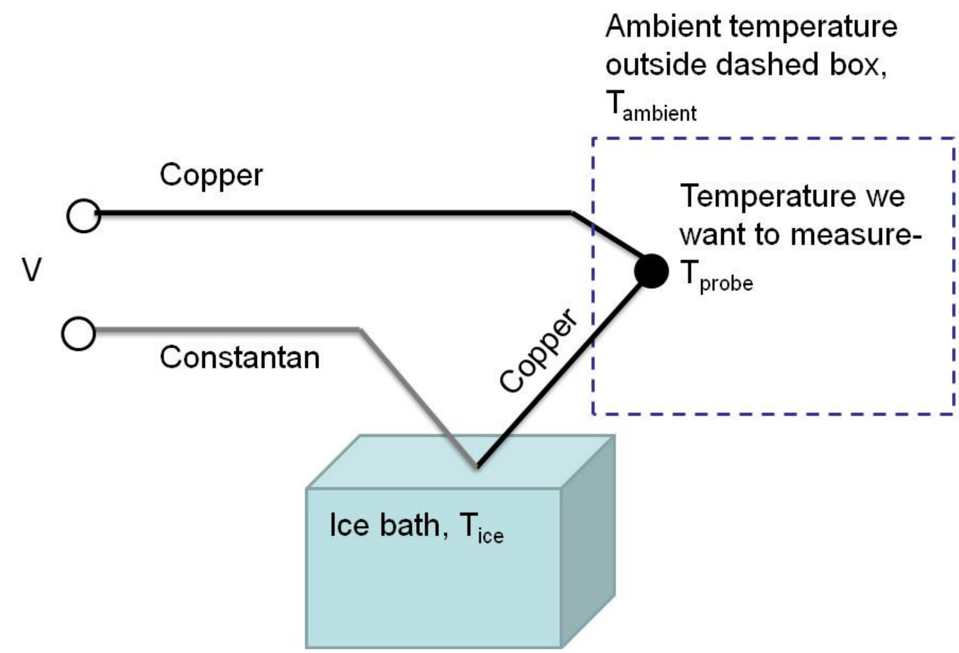
$$\Delta V = \alpha \Delta T$$

$$\alpha \equiv \text{coeffiecient of voltage change with temperature change}$$

$$\Delta V = \Delta V_{\text{copper}} + \Delta V_{\text{constantan}}$$

$$\Delta V = \left(\alpha_{\text{copper}}\right)\left(T_{ambient} - T_{probe}\right) + \alpha_{\text{constantan}}\left(T_{probe} - T_{ambient}\right) = \left(\alpha_{\text{constantan}} - \alpha_{\text{copper}}\right)\left(T_{probe} - T_{ambient}\right)$$

As can be seen from the equation above, we are sensing the difference between T_{probe} and T_{ambient}, not T_{probe}. Wouldn't it be nice if we could replace T_{ambient}, which could change over time, with something a bit more stable? We can! An ice bath can be used in the configuration below. Follow through the math to see how the measured voltage is *independent* of *ambient temperature*.



$$\Delta V = \alpha \Delta T$$

$$\alpha \equiv \textit{coeffiecient of voltage change}$$

$$\Delta V = (\alpha_{\text{copper}})(T_{ambient} - T_{probe}) + \alpha_{\text{constantan}}(T_{probe} - T_{ice}) + (\alpha_{\text{copper}})(T_{ice} - T_{ambient})$$

$$= (\alpha_{\text{constantan}} - \alpha_{\text{copper}})(T_{probe} - T_{ice})$$